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Health and safety risks faced by delivery riders during the Covid-19 pandemic

Nguyen Anh Thuy Tran^a, Ha Lan Anh Nguyen^a, Thi Bich Ha Nguyen^a,
Quang Huy Nguyen^a, Thi Ngoc Lan Huynh^a, Dorina Pojani^b, Binh Nguyen Thi^c,
Minh Hieu Nguyen^{d,*}

^a Campus in Ho Chi Minh City, University of Transport and Communications, No. 450-451 Le Van Viet Street, Tang Nhon Phu A Ward, Thu Duc City, Ho Chi Minh City, Vietnam

^b School of Earth and Environmental Sciences, The University of Queensland, Brisbane, Australia

^c School of Economics and International Business, Foreign Trade University, Hanoi, Vietnam

^d Faculty of Transport - Economics, University of Transport and Communications, No. 3 Cau Giay Street, Dong Da District, Hanoi, Vietnam

ARTICLE INFO

Keywords:

Delivery riders
Covid-19 pandemic
Ho Chi Minh city
Last-mile delivery
City logistics
Working conditions

ABSTRACT

Objectives: Delivery riders have been front-line workers throughout the pandemic but little is known about their own health and safety during this time. This study explores the health and safety issues facing delivery riders in Ho Chi Minh City, Vietnam, during the Covid-19 pandemic, in particular during the second lockdown (May–October 2021).

Method: A web-based survey of more than 800 riders was conducted in August–September 2021. Following descriptive statistics, four logit models were fitted to examine the factors associated with (a) sanitizing one's hands, (b) using a face shield, (c) contracting a new health issue, and (d) engaging in riskier traffic behaviors during the lockdown.

Results: The riders who were less consistent in adopting health and safety measures tended to be male, older, less-educated, and vaccinated. Also, they were under greater financial pressure and had suffered a larger loss of income during the pandemic. To recover the loss, they worked longer hours and felt under more intense pressure at work. The job pressure, long working hours, and financial burdens led many drivers to adopt risky traffic behaviors, such as speeding. Conversely, where the companies and co-workers were more supportive, riders tended to adopt health prevention measures more often. Fear of Covid-19 also acted as a facilitator. Job and financial pressure combined with the fear of contracting the virus contributed to the occurrence of new health issues during the pandemic. Again, support from the company and co-workers helped to reduce the risk of new health problems emerging.

Conclusion: In Ho Chi Minh City and other Global South megacities that employ tens of thousands of riders, ensuring their health and safety is important to support both private businesses and public health. Overall, companies should assume a much larger responsibility here.

* Corresponding author.

E-mail addresses: d.pojani@uq.edu.au (D. Pojani), ntbinh@ftu.edu.vn (B. Nguyen Thi), hieunm@utc.edu.vn (M.H. Nguyen).

1. Introduction

The Covid-19 pandemic has posed a major threat to the urban economies and logistics, in addition to public health. Peter Goodman (2021) writes in the *New York Times* (23 October 2021):

“Computer chips. Exercise equipment. Breakfast cereal. By now, you’ve probably heard: The world has run short of a great many products. In an era in which we’ve become accustomed to clicking and waiting for whatever we desire to arrive at our doors, we have experienced the shock of not being able to buy toilet paper, having to wait months for curtains and needing to compromise on the color of our new cars.”

Where supply chains are broken due to people’s limited access to goods (such as during a lockdown), manufacturers, retailers, and food outlets can go bankrupt. In this context, delivery drivers and riders - the ‘last mile link’ of the supply chain - have emerged as front-line workers, akin to doctors and nurses. Their services have sustained businesses while allowing people to self-isolate at home and lower the general risk of exposure to the virus. Yet, the health and safety concerns of delivery workers themselves have received little consideration and support (Airolidi et al., 2021; Ortiz-Prado et al., 2021). On the contrary, their work conditions have deteriorated substantially, with workloads increasing, and pay remaining stable or declining.

In the literature, a handful of studies that focus on the use of personal protective equipment target public transport passengers or the general public rather than delivery workers (Dzisi and Dei, 2020; Guellich et al., 2021; Machida et al., 2020; Manh et al., 2021; Nguyen and Pojani, 2021). While increased work pressures can deteriorate one’s health (Nahrgang et al., 2011), no studies have been conducted on the health status of delivery riders (apart from studies documenting Covid-19 infection rates). Traffic behaviour has become more erratic during the pandemic, leading to safety concerns (e.g., Katrakazas et al., 2020) but this issue has not been studied in the context of delivery work.

To explore the issues facing delivery riders during the pandemic, we have conducted a survey-based study in Ho Chi Minh City. We have examined: (a) the attitudes and perceptions of risk (related to Covid-19, occupational health, and traffic crashes) among delivery riders during the pandemic, and (b) the resulting risk behaviors (i.e., self-protection measures such as hand sanitizing and use of face shields) which riders have taken to cope with the situation. Vietnamese megacities are a suitable location for this type of study because in the last decade the country has experienced a boom of e-commerce and accompanying delivery services (Huynh, 2020; VECOM, 2021). As such, the findings are widely applicable beyond Vietnam – certainly to other the Global South settings. Before proceeding to the empirical study, we provide some background on the nature of delivery work before and during the Covid-19 pandemic, present the conceptual framework that guided this study, and introduce the case study setting.

1.1. Background: Urban delivery services before and during the Covid-19 pandemic

E-shopping has grown in tandem with the Internet – in both developed and developing countries (Statista, 2018; UNCTAD, 2021). Not only has this growth affected individual travel demand but it has also given rise to a new urban transport service: ‘deliveries’ - the offline process of carrying the goods ordered online to customers (Dias et al., 2020; Ferrell, 2005; Le et al., 2021; Nguyen et al., 2021; Saphores and Xu, 2020; Shi et al., 2021; Zhou et al., 2014). These goods vary from lunch boxes to large domestic appliances, and are transported in an assortment of vehicles ranging from large vans to mopeds. Delivery workers can be independent (freelance) contractors or employees. Their employers include online marketplaces (such as Amazon), specialized delivery companies (such as Deliveroo), or individual shops and/or restaurants. Meituan Waimai, one of the largest delivery companies in China, employs nearly 4 million delivery riders (Huang, 2021). Remuneration is often based on delivery volumes rather than a fixed weekly/monthly rate or the number of hours spent on the job.

Becoming a delivery driver or rider is relatively easy. The job requires few skills and the barriers to entry are low. New employees only need a driver’s license (if using a car), access to a vehicle, and a smartphone. Many digital platforms, shops, and restaurants provide their delivery drivers and/or riders with a vehicle (van, motorcycle, or e-bike) painted with their logo but some do not. Freelance delivery workers usually have their own vehicles. Most digital platforms, shops, and restaurants use dedicated apps which delivery workers are required to install in order to manage orders. In some cases, this type of work is considered as temporary. For example, in Korea a high proportion of delivery riders are teenagers interested in earning pocket money (Byun et al., 2020). In other cases, especially for unskilled men, it constitutes a career. In urbanizing countries, the delivery sector provides the first (and perhaps only) entry to employment for poor rural migrants (Huang, 2021).

While delivery jobs are easily obtained, they are also precarious, physically demanding and mentally stressful – particularly for motorcycle and e-bicycle riders, who are more exposed to traffic and weather elements than car drivers. Delivery demand tends to increase in increment weather (e.g., heavy snow, pouring rain, high wind, stifling humidity, or scorching heat) when people are less willing to go out to shops or restaurants. This means that delivery workers tend to face more extreme weather conditions than other travelers. Also, demand rises during holidays, weekends, and evenings (when daytime workers return home). Peak working times for delivery workers coincide with those periods of the month/year when others relax and spend time with their families (Heiland, 2021).

Where dispatching apps are employed, the algorithms veer toward labor intensification (Huang, 2021). The systems are single-blind, meaning that riders are in the dark about the risk profiles of the delivery zones to which they are assigned. To meet customers’ expectations of rapid deliveries, earn more money by completing more orders, and avoid the hefty fines imposed by companies in case of delays, drivers and riders adopt a series of risky behaviors (Cant, 2020; Janjevic and Winkenbach, 2020; Wood et al., 2019). They speed, use their mobile phones while operating their vehicles, run red lights, skip lunch and bathroom breaks, and work non-stop (Qin et al., 2021; Wu and Loo, 2016; Zheng et al., 2019). A study based in China found that delivery riders worked, on average, 9.1 h/per day, 6 days per week; as a consequence many were exhausted and slept poorly at night (Zheng et al., 2019).

The relationship between delivery services and traffic congestion is unclear. Studies have tended to focus on the effect of congestion on delivery operations rather than the latter's contribution to congestion (Kellner, 2016; Sankaran et al., 2005). Some studies maintain that the availability of delivery services reduces the total amount of travel in a city, as deliveries replace and consolidate individual trips to shops and restaurants; possibly, this mitigates congestion (Le et al., 2021; Nguyen et al., 2021). However, delivery services can be rather fragmented and uncoordinated with different businesses employing their own staff, thus resulting in redundant and somewhat chaotic trips, especially in inner cities (Alvarez et al., 2018; Hammami, 2020; World Economic Forum, 2020).

The Covid-19 outbreak has exacerbated problems in the delivery sector (UNCTAD, 2021). Due to public anxiety about infection, mandated lockdowns, and widely applied mobility restrictions, e-commerce transaction have skyrocketed (Barnes, 2020; Beck et al., 2020; Koch et al., 2020; Molloy et al., 2021; Nguyen et al., 2021; Pollard and O'Neill, 2020). While this has provided more employment for delivery workers than ever before, it has also exposed them (and consequently their customers) to extra health and safety risks. For example, given less congested roads during lockdowns, riders tend to speed, and generally, the risk of serious or even fatal crashes increases with higher vehicular speeds (Aarts and van Schagen, 2006; Yu and Abdel-Aty, 2013).

Many riders and drivers have been forced to work longer hours than before and serve high-risk customers and zones, including hospitals and quarantine facilities. For example, according to Hadden (2020), many Amazon drivers are so busy that they have no time wash their hands and sanitize their vans. Possibly, the number of Covid-19 cases among delivery workers has been underreported by companies and some drivers and riders have acted as virus spreaders (Palmer, 2020; Nguyen and Vu, 2020). For instance, *Global Times*, a Chinese newspaper, announced that a 47-year-old delivery rider serving a large area of Beijing completed fifty orders per day during 17 consecutive days in June 2020 before he tested positive for Covid-19 (Liu and Cao, 2020). In a study set in Ecuador, 15% of the surveyed food delivery riders tested positive for Covid-19 (Ortiz-Prado et al., 2021).

Yet many have to keep working as they have no other source of income. The general population is aware of the problem and, in some places, is known to refer to delivery workers derogatorily as 'virus carriers'. Delivery companies have responded poorly to these concerns or have shifted the responsibility for ensuring public health and safety onto the workers themselves. A study set in China found that delivery riders had to purchase their own protective gear and sanitizing products to be eligible for work (Huang, 2021). Under these circumstances, one can expect the health and wellbeing of delivery workers to be compromised but research in this space is still limited. This study, set in Ho Chi Minh City, aims to fill this gap.

1.2. Conceptualization: Risk attitudes, perceptions, and behaviors

This study was inspired by a model of risk, formulated by van Winsen et al. (2011), and illustrated in Fig. 1. The model connects objective factors such as real risk and risk outcome to cognitive and psychological factors such as risk attitude, perception, and behavior. The latter are presumably moderated by demographic and employment characteristics. Risks can be of many types: financial, medical, environmental, and so forth. In this study we focus on health and safety risks in particular. Given that the present study is based on a survey of delivery riders, we do not measure the real health and safety risks associated with delivery work, nor the outcomes of those risks. We focus on the attitudes, perceptions, and behaviors of delivery riders when faced with myriad risks including illness, traffic accidents, job burnout, or income loss. We examine correlations rather than casual links.

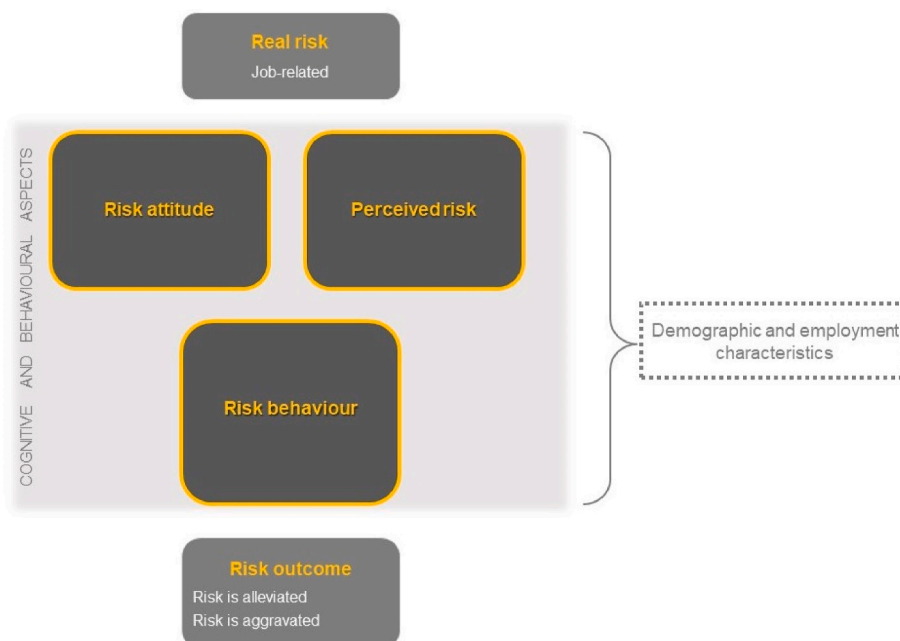


Fig. 1. Conceptualization: Risk attitudes and behaviors among delivery riders.

1.3. Case study setting: Ho Chi Minh City

Formerly known as Saigon, Ho Chi Minh City (HCMC) is the second largest and most populous city in Vietnam. While Hanoi is the seat of government, HCMC is the most important commercial center in the country. Located on the southern coast, it has more than 9 million inhabitants and covers more than 2000 square km (General Statistics Office, 2020). Private vehicle ownership is high at 900 vehicles per 1000 inhabitants (Nguyen et al., 2019). Of these, more than 90% are motorcycles (Huynh, 2020). Car and bus use is low at 1% and 5% respectively. Bicycles are used in 8% of trips (Leung and Le, 2019). Under normal circumstances, about 63,000 delivery riders operate in the city (Nguyen N., 2021). All use motorcycles and ride at 40–60 km/h. Overall, the city is bustling with traffic and crowds. In a tropical climate, daily travel is affected by floods, with about 1250 inundations recorded between 2010 and 2016 (Duy et al., 2019).

Since the Covid-19 outbreak, HCMC has experienced two lockdowns. The first, mandated nationwide, took place in April 2020 (Nguyen and Pojani, 2021). The second was mandated by the local government in May 2021 upon the detection of a hot spot. Between the two lockdowns, HCMC was relatively safe with rare cases of community infections. During the second lockdown, the number of daily cases fluctuated between 4000 and 7000 (Fig. 2). The peak (8400 cases) was reached in September. The lockdown was lifted in October 2021 once the number of cases dropped to several hundred per day. Now, most of the infected people are quarantined.

During the lockdown, travel was strictly prohibited for residents in hot spots, which were quite numerous. On some days, travel was totally banned citywide from 6 p.m. to 6 a.m. Not being able to shop in person, many people had to rely on delivery riders, even for their groceries (Fig. 3). But according press estimates, only 20,000–25,000 riders were permitted to circulate in the city during the lockdown. The government deployed some military personnel to deliver food and other goods to the needy. In some periods, each delivery rider was allocated to a specific district (Nikkei Asia, 2021). The overall efficiency of delivery services declined because, in addition to a much reduced number of riders, some roads were closed to traffic and some customers (e.g., those living in gated communities) could not be accessed as easily as before.

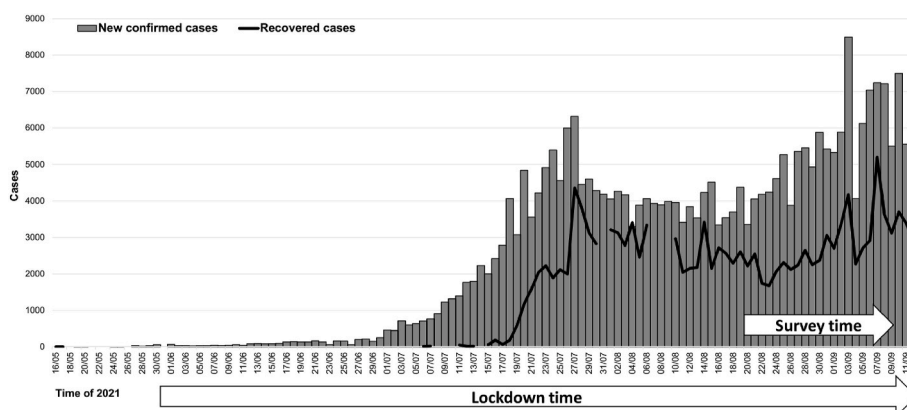


Fig. 2. Covid-19 timeline in HCMC. Graph by authors based on statistics by the Vietnamese Ministry of Health.



Fig. 3. Delivery rider wearing plastic gloves, a face mask, and a face shield during the lockdown. Photo by authors.

2. Method

The data collection and analysis procedures, as well as the key findings, are discussed below.

2.1. Data collection

This study is based on a survey of delivery riders in HCMC.¹ The survey questions (see [Tables 1 and 2](#) later) were meant to measure the (a) risk attitudes (b) risk perceptions and (c) risk behaviors of delivery riders, in line with the conceptual framework set forth earlier (see [Fig. 1](#)). The data were collected in August–September 2021, during the second lockdown. Given that it was impossible to conduct face-to-face interviews at that time, the questionnaire was administered online through Google Forms. Participants were recruited via snowball sampling by initially sending invitations to local delivery rider groups on Facebook, with a request to share the invitations with co-workers. A total of 1000 invitations to participate in the study were sent, and 806 completed forms were received. Because all questions were marked as mandatory, there were no missing data.

Table 1
Descriptive statistics.

Variables	Value	Freq.	%
<i>Demographic and employment variables</i>			
Gender	Female	42	5.2
	Male	764	94.8
Age (continuous variable)		30.81 ^a	8.2 ^b
University degree	No	576	71.5
	Yes	230	28.5
Homeowner	No	512	63.5
	Yes	294	36.5
Living in urban district	No	96	11.9
	Yes	710	88.0
Internal migrant	No	279	34.6
	Yes	527	65.4
Living with older persons (over 55)	No	526	65.3
	Yes	280	34.7
Living with at least one child (under 12)	No	350	43.4
	Yes	456	56.6
Loss of income during lockdown	<10%	173	21.5
	10–30%	190	23.6
	>30%	443	55.0
Only source of income in household	No	345	42.8
	Yes	461	57.2
Weekly working days (continuous variable)		5.97 ^a	1.2 ^b
Daily working hours	≤6	176	21.8
	>6 - <9	419	52.0
	≥9	211	26.2
Working area	Urban districts	348	43.2
	Non-urban districts	48	6.0
	Both urban and non-urban districts	410	50.9
<i>Health and safety variables</i>			
Vaccinated against Covid-19	No	236	29.3
	Yes	570	70.7
Covid-19 infection history	No	806	100
	Yes	0	0
Allergic to hand sanitizer	No	754	93.6
	Yes	52	6.5
Preexisting chronic conditions (e.g., diabetes, hypertension, cancer, and heart disease)	No	670	83.1
	Yes	136	16.9
Incidence of new health issue during lockdown (e.g., backpain, fatigue, insomnia, headaches)	No	507	62.9
	Yes	299	37.1
Frequency of hand sanitizing on the job	Infrequent (after 5+ orders)	104	12.9
	Frequent (after 3-4 orders)	246	30.5
	Regular (after 1-2 orders)	456	56.6
Use of face shield on the job	No	415	51.5
	Yes	391	48.5
Riskier traffic behaviors during lockdown (compared to before)	No	212	26.3
	Yes	594	73.7

^a Mean.

^b Standard deviation.

¹ In HCMC, deliveries take place by motorcycle as opposed to bicycle or car.

Table 2
Results of exploratory factor analysis (EFA).

Items	Mean	SD	Factors extracted		
			Fear of Covid-19	Support from company & co-workers	Work pressures
My colleagues remind me of taking preventive measures	4.0	1.3		0.7614	
My company provides sufficient hand sanitizer for me	3.5	1.5		0.8027	
My company reminds me of taking preventive measures	3.8	1.4		0.9223	
I believe that Covid-19 is a dangerous disease	5.1	1.4	0.8617		
I believe that Covid-19 infections are serious	5.0	1.3	0.8327		
I believe that the risk of Covid-19 infection is high at the moment	5.1	1.4	0.8782		
I try to complete as many orders as possible to increase my income	4.9	1.2			0.8303
I am always worried about the penalties due to late delivery	4.8	1.3			0.7961
I am always worried about the risk of late delivery while working	4.9	1.2			0.8812

Notes.

Sample size: 806.

Bartlett's Test of Sphericity: chi-square (2601.245); degrees of freedom (36); p-value (0.000); H_0 : variables are not intercorrelated.

Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy: 0.668.

Method: principal-component factors with eigenvalue >1.

Rotation: orthogonal oblimin (Kaiser on).

Retained factors = 3.

Variance explained by six factors extracted: 0.7180 (72%).

Score estimation method: Regression.

SD: Standard Deviation.

The questionnaire was structured in three parts. The **first part** collected demographic and employment data, including gender, age, educational attainment, living area, migrant status, presence of children (under 12) or older adults (over 55) at home, income loss during lockdown, household income sources, amount of work hours/days, and working areas. These questions were adapted from the existing literature. Existing studies have found that the level of adoption of Covid-19 prevention measures depends on gender, income, age (Machida et al., 2020), education level (Yildirim et al., 2021), living area (i.e., rural vs urban) (Nguyen and Pojani, 2021), and living arrangements (i.e., alone or with others) (Machida et al., 2020). Studies of delivery riders have found that the adoption of traffic safety measures is associated with age, educational achievement (Nguyen-Phuoc et al., 2020), time pressures on the job (Wu and Loo, 2016), and level of fatigue (Papakostopoulos and Nathanael, 2021; Zheng et al., 2019). A question on income loss was included because this has been common during the pandemic and has affected all workers in myriad ways (Nguyen et al., 2021). Finally, a question on the migration status of riders was included because they are known to come to Ho Chi Minh City from the hinterland.

The **second part** collected health and safety data including Covid-19 infection history, Covid-19 vaccination, allergies (to hand sanitizer), preexisting chronic conditions (e.g., diabetes, cardiovascular disease, cancer), incidence of new health issues during the lockdown (e.g., backpain, chronic fatigue, insomnia, headaches). Some questions focused on behaviors more specifically: frequency of hand sanitizing on the job, use of a face shield on the job,² and frequency of engaging in risky traffic behaviors (i.e., red-light running, using a mobile phone while riding, riding illegally on one-way streets, neglecting turn signals, and speeding) before and during the lockdown. Again, this set of questions was designed based on a review of the literature. Humans are known to adopt coping strategies selectively to deal with stressful conditions – such as a pandemic (Homburg and Stolberg, 2006). People with existing health issues are more likely to comply with Covid-19 prevention measures (Nguyen and Pojani, 2021; Nguyen et al., 2020). So are people who fear infection the most (Nguyen and Armoogum, 2021; Yildirim et al., 2021).

The **third part** of the questionnaire comprised nine statements measured on a 7-point Likert scale. Three statements probed into the health and safety attitudes prevailing in the rider's company and coworker circle. Workplace characteristics are known to determine risk outcomes (Demerouti et al., 2001); stressful and demanding jobs lead employees to neglect safety recommendations (Nahrgang et al., 2011). Conversely, the support of companies and co-workers is known to reduce job demands and thus minimize burnout and risk-taking (Bronkhorst, 2015; Nahrgang et al., 2011). Three additional statements sought to measure perceptions such as fear of Covid-19 (based on Dryhurst et al., 2020; Nguyen 2021; Yildirim et al., 2021). Three final statements, adapted from Demerouti et al. (2001) and Zheng et al. (2019) centered on the perceptions of work pressures which might distract delivery riders on the job and thus reduce safety.

The questionnaire was initially designed in English and then translated into Vietnamese. A group of Vietnamese transport experts were asked to review the translated version, which was then pre-tested with five delivery riders. This pilot having raised no issues, a large-scale survey was conducted.

² Face shields are clear plastic barriers covering the face. They are cheaply produced in Vietnam and are recommended by the World Health Organization to provide protection from airborne contaminants and droplets (Perencevich et al., 2020; World Health Organization, 2020).

2.2. Data description

Table 1 provides an overview of the data collected through the first and second part of the questionnaire. As elsewhere (Huang, 2021; Ortiz-Prado et al., 2021), delivery riders in HCMC were overwhelmingly male, younger, and relatively poor. Most had recently moved to the big city from the countryside and this job was their first entry point into the urban employment market. More than half were the sole providers for their families, which often included children and elderly parents. Their living expenses were high as nearly two thirds rented their home in the city, while their household incomes had declined substantially during the pandemic. To compensate, delivery riders worked harder than before, about 6 days per week on average, with about a quarter working more than 9 h per day. More than half delivered packages across the vast metropolitan area, and during the lockdown their driving behaviors had become riskier. Moreover, many had contracted a new, likely stress-related, health issue, such as backpain, fatigue, insomnia, or headaches. On the positive side, no study participant had ever tested positive for Covid-19, and a high proportion were already vaccinated at the time of the study. (Vaccinating delivery riders has been a government priority in Vietnam.) All riders complied with the requirement to wear a face mask and nearly half used a face shield in addition to the mask. Most reported being diligent about sanitizing their hands – to protect others and themselves (approximately 17% live with a chronic disease).

2.3. Data reduction

We applied exploratory factor analysis (EFA) to attitudinal statements (the third part of the questionnaire) with orthogonal oblimin rotation (Kaiser on) and principal components analysis extraction (eigenvalue >1). The Kaiser-Meyer-Olkin measure (KMO = 0.668) confirmed the sampling adequacy. All KMO values for individual items were over 0.6, which is well above the acceptable limit of 0.5 (Hutcheson and Sofroniou, 1999; Kaiser, 1974; Tabachnick and Fidell, 2000). The results of Bartlett's test of sphericity (see notes under Table 2) indicated that correlations between items were sufficiently large for EFA. The three retained constructs, which explained 72% of the data variance, were named: fear of Covid-19; support from company and co-workers; and work pressures (Table 2). The statistical means of the items within each construct suggest high fear of Covid-19, high work pressure among delivery riders, and relatively poor support from their colleagues and companies.

2.4. Data modelling

The survey data and the psychological constructs were modelled into four logistic regressions, ordinal or binary. The respective dependent variables were the following:

- 1) Frequency of hand sanitizing on the job. The ordinal categories were 1 = infrequent (after 5 orders or more); 2 = frequent (after 3-4 orders), 3 = regular (after 1-2 orders).
- 2) Use of face shield on the job. The binary categories were 0 = no and 1 = yes.
- 3) Incidence of new health issue during lockdown. The binary categories were 0 = no and 1 = yes.
- 4) Riskier traffic behaviors. The binary categories were 0 = no and 1 = yes.

We conducted a few statistical tests to ensure that these four models were robust. For Model 1, the Brant test yielded non-significant results (see notes under Table 3), indicating that the use of ordinal logit regression was acceptable in this case (Nguyen and Pojani, 2022a). For all Models, we calculated the variance inflation factors (VIFs) to measure the amount of multicollinearity across independent variables. All VIFs were less than 1.5, indicating low risk of multicollinearity (Nguyen and Pojani, 2022b).

2.5. Study limitations

While being rigorously designed and conducted, the study suffers from the typical biases present in online surveys. Note that, while large, the study sample is not random; this means that the results may not be generalizable to the entire population of delivery riders in HCMC. While a conceptual framework based on risk was used as a basis here, future studies might employ a more targeted occupational model, such as Job Demands and Resources (JD-R). Because our main tool is regression analysis, we could only establish correlations between the factors. Should the data permit it, future studies could employ Structural Equation Modelling to establish the causal links between risk attitudes, perceptions, and behaviors.

3. Findings

3.1. Interpretation of results

Table 3 presents the results of Models 1–4. We elaborate on those results below.

First we tackle **demographic and employment variables**. As noted, the share of female riders participating in the study was miniscule (5%). However, we found that women were more likely than men to take protective measures such as sanitizing their hands frequently, using a face shield (in addition to a face mask), and riding more cautiously. These findings are in line with previous studies on health and traffic behavior (Jensupakarn and Kanitpong, 2018; Machida et al., 2020; Rana et al., 2021). They confirm the widespread theory that women are more averse to risk, often due to socialization in patriarchal cultures (Liu and Zuo, 2019).

Table 3
Modelling results.

Variable	Model 1: Frequency of hand sanitizing			Model 2: Use of face shield			Model 3: Incidence of new health issue			Model 4: Riskier traffic behaviors		
	Coef.	Std.	p	Coef.	Std.	p	Coef.	Std.	p	Coef.	Std.	p
<i>Demographic and employment variables</i>												
Gender (ref = female)	−1.041**	0.476	0.028	−0.748*	0.395	0.058				0.912**	0.361	0.011
Age	−0.024**	0.011	0.030	−0.029**	0.011	0.011	−0.023**	0.011	0.043			
University degree (ref = no)	0.469**	0.191	0.014							−0.334*	0.192	0.082
Homeowner (ref = no)				0.379*	0.201	0.059	−0.428**	0.195	0.028	−0.542**	0.211	0.010
Living in urban district (ref = no)												
Only source of income in household (ref = no)				0.618**	0.189	0.001	0.645**	0.183	0.000	0.464**	0.198	0.019
Loss of income (ref = <10%)												
10%–30%												
>30%	−0.605**	0.227	0.008	−0.447**	0.216	0.038				−0.470**	0.230	0.041
Internal migrant (ref = no)										0.456**	0.214	0.033
Living with older persons (ref = no)				0.318*	0.185	0.086						
Living with at least one child (ref = no)												
Weekly working days							0.225**	0.078	0.004	0.204**	0.076	0.007
Daily working hours (ref = <6)												
6 - under 9	−0.617**	0.230	0.007									
≥9	−0.833**	0.257	0.001	−0.587**	0.252	0.020	0.469**	0.240	0.049	0.628**	0.283	0.027
Working area (ref = Urban district)												
Non-urban district												
Both urban and non-urban districts				−0.340**	0.177	0.048	0.509**	0.174	0.003			
Work pressures ^a	−0.207**	0.080	0.010				0.288**	0.083	0.000	0.211**	0.089	0.018
<i>Health and safety variables</i>												
Allergic to sanitizer (ref = no)	−0.873**	0.323	0.007	2.050**	0.381	0.000						
Preexisting chronic conditions (ref = no)	0.611**	0.239	0.010	0.905**	0.226	0.000	0.410**	0.210	0.048			
Vaccinated (ref = no)	−0.898**	0.203	0.000									
Support from company and co-workers ^a	0.692**	0.092	0.000	0.593**	0.090	0.000	−0.218**	0.085	0.010			
Fear of Covid-19 ^a	1.153**	0.094	0.000	0.411**	0.086	0.000	0.213**	0.084	0.011			
/cut1	−5.805	0.791										
/cut2	−3.303	0.770										
_cons				1.196	0.679	0.078	−1.871	0.672	0.005	−1.518	0.689	0.027
Log likelihood	−563.14161			−461.89557			−476.88687			−413.38948		
LR chi ² (22)	402.99			192.85			109.29			102.05		
Prob > chi ²	0.0000			0.0000			0.0000			0.0000		
Pseudo R ²	0.2635			0.1727			0.1028			0.1099		

Notes.

N = 806.

Only significant variables are presented in Table 3.

Brant test result (applied for model 1): chi²: 30.41, df: 22, p > chi²: 0.109.

Values of dependent variable in Model 1: 1 = Infrequent, 2 = Frequent (sanitizing after 3-4 orders on average), 3 = Regular (sanitizing after 1-2 orders on average).

Values of dependent variable in Model 2: 1 = Yes, 0 = No.

Values of dependent variable in Model 3: 1 = Yes, 0 = No.

Values of dependent variable in Model 4: 1 = Yes, 0 = No.

**95%; *90%.

^a Derived from EFA.

Older riders (who tended to be less educated) were less likely to sanitize their hands or use a face shield. This was quite surprising because the Vietnamese media have repeatedly conveyed the message that the risk of serious illness from Covid-19 increases with age. Perhaps this finding is not due to carelessness but to the fact that older people are more likely to wear eyeglasses, which prevent them from wearing a shield.

Education appeared to enable the adoption of health and safety measures. Possibly, university-educated riders were more aware of the risks associated with both Covid-19 infections and traffic infractions. Studies on the traffic behaviors of motorcyclists in Vietnam (Nguyen-Phuoc et al., 2020) and Malaysia (Borhan et al., 2018) have reached similar conclusions.

Riders whose families had lost the most income during the lockdown were less likely to use hand sanitizer or wear a face shield (which they have to purchase on their own). The explanation could be that, while these items are relatively cheap by middle-class standards, they could impose a financial burden on poor riders whose livelihood is precarious. At the same time, riders who had faced the most financial loss during the lockdown tended to ride more slowly and carefully. While this means completing fewer orders (and thus earning less), it also ensures a steady source of income for family. (A traffic crashes under these circumstances could place an entire family on the brink of financial ruin.) A high level of concern for the family is also suggested by the finding that riders who were the only source of household income were more likely to wear a face shield to protect their health. So were riders who lived with older adults (their parents or simply roommates), who are known to be at a higher risk of complications from Covid-19.

On the other hand, longer work hours, larger geographic coverage for deliveries, and stronger feelings of work pressure led riders to take fewer health and safety precautions – such as sanitizing hands, wearing face shields, and riding carefully. In particular, the push to complete as many orders as possible so as to earn more money led riders to adopt riskier traffic behaviors during the lockdown. This was clearly driven by their financial circumstances: riders who had to pay rent (usually migrants) and those who were the sole breadwinners in their family were more likely to ride dangerously. This suggests that fatigue, stress, and poverty among the workforce undermine both disease containment measures and traffic regulations – a conclusion also reached by Ortiz-Prado et al. (2021), Nguyen-Phuoc et al. (2020), and Zheng et al. (2019).

With regard to **health and safety variables**: unsurprisingly, riders who were allergic to hand sanitizer avoided it. However, to compensate, they were more inclined to use a face shield. Those riders who had chronic diseases were more likely to use both hand sanitizer and face shields, probably knowing that their risk of Covid-19 complications was higher. So were riders who were generally more concerned about becoming infected.

Riders who were already vaccinated appeared to have become somewhat careless in terms of using hand sanitizer and face shields. This is a problematic finding because, while Covid-19 vaccination is known to reduce the risk and severity of infections, riders are still vulnerable to the virus and can also spread it among their customers (Sultana et al., 2020). But where companies were supportive and reminded riders to take preventive measures and not become complacent, the rate of hand sanitizer and face shield use went up.

While no riders in our sample had contracted Covid-19, nearly 63% had experienced new health issues during lockdown, such as backpain, fatigue, insomnia, or headaches. These appeared to be stress-related (at least in part) as they were more prevalent among people with pre-existing chronic conditions, younger riders (probably due to longer work hours and a lack of work experience), riders covering larger delivery zones, and workers with larger financial burdens (such as renters). But where the work environment was supportive, the incidence of new health issues among riders was reduced. Again, this suggests that stress had a large role to play.

3.2. Policy recommendations

Based on the findings of this study, we recommend several policy measures:

- Companies should pay their riders a monthly living wage (rather than a piece rate tied to customer ratings) so that workers are not too rushed and stressed to take precaution measures (sanitizing their hands and vehicles and using face masks and shields) and obey traffic rules. For a similar reason, companies should reduce penalties for late deliveries. During lockdowns, delivery riders should be paid extra to account for the risk taken.
- The workhours should be capped to a reasonable amount, even during the pandemic, following local regulations and guidance. (In Vietnam, the workweek is capped at 48 h but the government encourages employers to apply 40-h workweeks.) Delivery workers should be allowed to take paid breaks during the workday. In addition, working time should account for the fact that during a pandemic, delivery riders need extra time to sanitize their hands, vehicles, and packages.
- Companies should be required to adopt detailed and strict health and safety plans. They should also provide regular reminders (and, in the case of large companies, trainings) on the importance of following health and safety rules during work. The cost of protective equipment should be borne by companies rather than employees. Where technology is available, contact-free delivery and digital payments should be practiced (Nguyen and Vu, 2020). Technology (e.g., GPS) should also be used to monitor riders' traffic behaviors and send warnings if road rules are broken (Nguyen and Armoogum, 2020). However, considering currently exploitative work conditions, we are loath to recommend that this information be tied to the salary of riders.
- Delivery workers should be prioritized during immunization campaigns. Riders who are already inoculated against Covid-19 should be educated on the limits of vaccines so that they continue to take preventive measures while working.
- Companies should have a duty of care to their delivery workers and riders' health status should be considered when assigning tasks. Persons with chronic diseases and compromised immune systems, who need to avoid high-risk zones (Bogani et al., 2020; Clark et al., 2021; Li et al., 2020; Remuzzi and Remuzzi, 2020), should be accommodated within reason.

If adopted, most of these policies should remain in place after the Covid-19 pandemic. Overall, companies should assume a much

larger responsibility in ensuring the health and safety of their delivery workers. Further studies should focus on employers rather than the riders themselves.

4. Conclusion

This study is among the first to employ primary data from a large survey in order to elucidate the health and safety risk perceptions, attitudes and behaviors among delivery riders in the Covid-19 pandemic era. A summary of the findings follows.

The riders who were less consistent in adopting health and safety measures tended to be male, older, less-educated, and vaccinated. Also, they were under greater financial pressure and had suffered a larger loss of income during the pandemic. To recover the loss, they worked longer hours and felt under more intense pressure at work. The job pressure, long working hours, and financial burdens led many drivers to adopt risky traffic behaviors, such as speeding. Conversely, where the companies and co-workers were more supportive, riders tended to adopt health prevention measures more often. Fear of Covid-19 also acted as a facilitator. Job and financial pressure combined with the fear of contracting the virus contributed to the occurrence of new health issues during the pandemic. Again, support from the company and co-workers helped to reduce the risk of new health problems emerging.

While delivery riders have placed themselves at risk to help sustain the urban economy and meet the daily needs of fellow urbanites during the Covid-19 lockdowns, their own work conditions (and health) have deteriorated and their livelihoods have become increasingly precarious. In Ho Chi Minh City and other Global South megacities that employ tens of thousands of riders, ensuring their health and safety is important to support both private businesses and public health (Nguyen et al., 2021). To this end, we have provided a series of policy recommendations.

Author contributions

Conceptualization, MHN, DP, NATT, HLAN, TBHN, QHN, TNLH; methodology, NATT, HLAN, TBHN, QHN, TNLH, DP, MHN; data collection, NATT, HLAN, TBHN, QHN, TNLH, MHN; formal analysis, all authors; writing, all authors. All authors have read and agreed to the published version of the manuscript.

Declaration of competing interest

None.

Data availability

The authors do not have permission to share data.

Acknowledgements

This research was funded by the Foreign Trade University, Hanoi, Vietnam (research program no.: FTURP02-2020-10). The authors thank the journal editor and the anonymous referees for their constructive feedback. The support of delivery riders in Ho Chi Minh City is highly appreciated.

References

- Aarts, L., van Schagen, I., 2006. Driving speed and the risk of road crashes: a review. *Accid. Anal. Prev.* 38, 215–224. <https://doi.org/10.1016/j.aap.2005.07.004>.
- Airoldi, C., Calcagno, A., Di Perri, G., Valinotto, R., Gallo, L., Locana, E., Trunfio, M., Patrucco, F., Vineis, P., Faggiano, F., 2021. Seroprevalence of SARS-CoV-2 among workers in Northern Italy. *Annals of work exposures and health*. <https://doi.org/10.1093/annweh/wxab062>.
- Alvarez, P., Lerga, I., Serrano-Hernandez, A., Faulin, J., 2018. The impact of traffic congestion when optimising delivery routes in real time. A case study in Spain. *Int. J. Logistics Res. Appl.* 21, 529–541. <https://doi.org/10.1080/13675567.2018.1457634>.
- Barnes, S.J., 2020. Information management research and practice in the post-COVID-19 world. *Int. J. Inf. Manag.* 55, 102175. <https://doi.org/10.1016/j.ijinfomgt.2020.102175>.
- Beck, M.J., Hensher, D.A., Wei, E., 2020. Slowly coming out of COVID-19 restrictions in Australia: implications for working from home and commuting trips by car and public transport. *J. Transport Geogr.* 88, 102846. <https://doi.org/10.1016/j.jtrangeo.2020.102846>.
- Bogani, G., Ditto, A., Bosio, S., Brusadelli, C., Raspagliesi, F., 2020. Cancer patients affected by COVID-19: experience from Milan, Lombardy. *Gynecol. Oncol.* 158, 262–265. <https://doi.org/10.1016/j.ygyno.2020.06.161>.
- Borhan, M.N., Ibrahim, A.N.H., Aziz, A., Yazid, M.R.M., 2018. The relationship between the demographic, personal, and social factors of Malaysian motorcyclists and risk taking behavior at signalized intersections. *Accid. Anal. Prev.* 121, 94–100. <https://doi.org/10.1016/j.aap.2018.09.004>.
- Bronkhorst, B., 2015. Behaving safely under pressure: the effects of job demands, resources, and safety climate on employee physical and psychosocial safety behavior. *J. Saf. Res.* 55, 63–72. <https://doi.org/10.1016/j.jsr.2015.09.002>.
- Byun, J.H., Park, M.H., Jeong, B.Y., 2020. Effects of age and violations on occupational accidents among motorcyclists performing food delivery. *WOR* 65, 53–61. <https://doi.org/10.3233/WOR-193057>.
- Cant, C., 2020. *Riding for Deliveroo: Resistance in the New Economy*. Polity. Medford, MA, Cambridge, UK.
- Clark, C.E., McDonagh, S.T.J., McManus, R.J., Martin, U., 2021. COVID-19 and hypertension: risks and management. A scientific statement on behalf of the British and Irish Hypertension Society. *J. Hum. Hypertens.* 35, 304–307. <https://doi.org/10.1038/s41371-020-00451-x>.
- Demerouti, E., Bakker, A.B., Nachreiner, F., Schaufeli, W.B., 2001. The job demands-resources model of burnout. *J. Appl. Psychol.* 86, 499–512.
- Dias, F.F., Lavieri, P.S., Sharda, S., Khoeini, S., Bhat, C.R., Pendyala, R.M., Pinjari, A.R., Ramadurai, G., Srinivasan, K.K., 2020. A comparison of online and in-person activity engagement: the case of shopping and eating meals. *Transport. Res. C Emerg. Technol.* 114, 643–656. <https://doi.org/10.1016/j.trc.2020.02.023>.

- Dryhurst, S., Schneider, C.R., Kerr, J., Freeman, A.L.J., Recchia, G., Bles, A.M. van der, Spiegelhalter, D., Linden, S. van der, 2020. Risk perceptions of COVID-19 around the world. *J. Risk Res.* 1–13. <https://doi.org/10.1080/13669877.2020.1758193>, 0.
- Duy, P.N., Chapman, L., Tight, M., 2019. Resilient transport systems to reduce urban vulnerability to floods in emerging-coastal cities: a case study of Ho Chi Minh City. *Vietnam. Travel Behav. Soc.* 15, 28–43. <https://doi.org/10.1016/j.tbs.2018.11.001>.
- Dzisi, E.K.J., Dei, O.A., 2020. Adherence to social distancing and wearing of masks within public transportation during the COVID 19 pandemic. *Trans. Res. Interdiscipl. Perspec.* 7, 100191. <https://doi.org/10.1016/j.trip.2020.100191>.
- Ferrell, C.E., 2005. Home-based teleshopping and shopping travel: where do people find the time? *Transportation research record*. <https://doi.org/10.1177/0361198105192600125>.
- General Statistics Office, 2020. *Statistical Yearbook of Vietnam*. Statistical Publishing House, Vietnam.
- Goodman, P.S., 2021. How the Supply Chain Broke, and Why it Won't Be Fixed Anytime Soon. *The New York Times*.
- Guellich, A., Tella, E., Ariane, M., Grodner, C., Nguyen-Chi, H.-N., Mahé, E., 2021. The face mask-touching behavior during the COVID-19 pandemic: observational study of public transportation users in the greater Paris region: the French-mask-touch study. *J. Transport Health* 21, 101078. <https://doi.org/10.1016/j.jth.2021.101078>.
- Hadden, J., 2020. Amazon delivery drivers share what its like to be on the front lines of the coronavirus pandemic, including not having time to wash their hands and uncleaned vans [WWW Document]. *Business Insider*. URL. <https://www.businessinsider.com/why-amazon-delivery-workers-feel-exposed-and-vulnerable-to-coronavirus-2020-3>, 9.28.2021.
- Hammami, F., 2020. The impact of optimizing delivery areas on urban traffic congestion. *Res. Transp. Bus. Manag.* 37, 100569. <https://doi.org/10.1016/j.rtbm.2020.100569>.
- Heiland, H., 2021. Neither timeless, nor placeless: control of food delivery gig work via place-based working time regimes. *Hum. Relat.*, 001872672111025283 <https://doi.org/10.1177/001872672111025283>.
- Homburg, A., Stolberg, A., 2006. Explaining pro-environmental behavior with a cognitive theory of stress. *J. Environ. Psychol.* 26, 1–14. <https://doi.org/10.1016/j.jenvp.2006.03.003>.
- Huang, H., 2021. Riders on the storm: amplified platform precarity and the impact of COVID-19 on online food-delivery drivers in China. *J. Contemp. China* 1–15. <https://doi.org/10.1080/10670564.2021.1966895>.
- Hutcheson, G., Sofroniou, N., 1999. *The Multivariate Social Scientist: Introductory Statistics Using Generalized Linear Models*. Sage Publications, London ; Thousand Oaks, Calif.
- Huynh, D., 2020. Making Megacities in Asia: Comparing National Economic Development Trajectories, SpringerBriefs in Regional Science. Springer Singapore, Singapore. <https://doi.org/10.1007/978-981-15-0660-4>.
- Janjevic, M., Winkenbach, M., 2020. Characterizing urban last-mile distribution strategies in mature and emerging e-commerce markets. *Transport. Res. Pol. Pract.* 133, 164–196. <https://doi.org/10.1016/j.tra.2020.01.003>.
- Jensupakarn, A., Kanitpong, K., 2018. Influences of motorcycle rider and driver characteristics and road environment on red light running behavior at signalized intersections. *Accid. Anal. Prev.* 113, 317–324. <https://doi.org/10.1016/j.aap.2018.02.007>.
- Kaiser, H.F., 1974. An index of factorial simplicity. *Psychometrika* 39, 31–36. <https://doi.org/10.1007/BF02291575>.
- Katrakazas, C., Michalaraki, E., Sekadakakis, M., Yannis, G., 2020. A descriptive analysis of the effect of the COVID-19 pandemic on driving behavior and road safety. *Trans. Res. Interdiscipl. Perspec.* 7, 100186. <https://doi.org/10.1016/j.trip.2020.100186>.
- Kellner, F., 2016. Insights into the effect of traffic congestion on distribution network characteristics – a numerical analysis based on navigation service data. *Int. J. Logistics Res. Appl.* 19, 395–423. <https://doi.org/10.1080/13675567.2015.1094043>.
- Koch, J., Frommeyer, B., Schewe, G., 2020. Online shopping motives during the COVID-19 pandemic—lessons from the crisis. *Sustainability* 12, 10247. <https://doi.org/10.3390/su122410247>.
- Le, H.T.K., Carrel, A.L., Shah, H., 2021. Impacts of online shopping on travel demand: a systematic review. *Transport Rev.* 1–23. <https://doi.org/10.1080/01441647.2021.1961917>.
- Leung, A., Le, T.P.L., 2019. Factors associated with adolescent active travel: a perceptive and mobility culture approach – insights from Ho chi Minh city, Vietnam. *Transportation research Part A: policy and practice, walking and cycling for better transport*. *Health Environ.* 123, 54–67. <https://doi.org/10.1016/j.tra.2018.09.004>.
- Li, J., Guo, T., Dong, D., Zhang, X., Chen, X., Feng, Y., Wei, B., Zhang, W., Zhao, M., Wan, J., 2020. Defining heart disease risk for death in COVID-19 infection. *QJM: Int. J. Med.* 113, 876–882. <https://doi.org/10.1093/qjmed/hcaa246>.
- Liu, C., Cao, S., 2020. Beijing deliveryman who sends 50 orders per day confirmed with COVID-19 - Global Times [WWW Document]. *global Times*. URL. <https://www.globaltimes.cn/content/1192565.shtml>, 9.29.2021.
- Liu, E.M., Zuo, S.X., 2019. Measuring the impact of interaction between children of a matrilineal and a patriarchal culture on gender differences in risk aversion. *Proc. Natl. Acad. Sci. Unit. States Am.* 116, 6713–6719. <https://doi.org/10.1073/pnas.1808336116>.
- Machida, M., Nakamura, I., Saito, R., Nakaya, T., Hanibuchi, T., Takamiya, T., Odagiri, Y., Fukushima, N., Kikuchi, H., Amagasa, S., Kojima, T., Watanabe, H., Inoue, S., 2020. Incorrect use of face masks during the current COVID-19 pandemic among the general public in Japan. *Int. J. Environ. Res. Publ. Health* 17, 6484. <https://doi.org/10.3390/ijerph17186484>.
- Manh, T.H., Duong, D.A., Anh, N.N., Duc, N.T., Minh, N.B., Huong, M.T., Hieu, N.M., 2021. Adherence to mask wearing on public transport during the COVID-19 pandemic and influential factors: the case of Hanoi. *Transport Commun. Sci. J.* 72, 486–497. <https://doi.org/10.47869/tcsj.72.4.8>.
- Molloy, J., Schatzmann, T., Schoeman, B., Tcherwenkov, C., Hintermann, B., Axhausen, K.W., 2021. Observed impacts of the Covid-19 first wave on travel behaviour in Switzerland based on a large GPS panel. *Transport Pol.* <https://doi.org/10.1016/j.tranpol.2021.01.009>.
- Nahrgang, J.D., Morgeson, F.P., Hofmann, D.A., 2011. Safety at work: a meta-analytic investigation of the link between job demands, job resources, burnout, engagement, and safety outcomes. *J. Appl. Psychol.* 96, 71–94. <https://doi.org/10.1037/a0021484>.
- Nguyen, D.C., Hoang, H.D., Hoang, H.T., Bui, Q.T., Nguyen, L.P., 2019. Modal preference in Ho chi Minh city, Vietnam: an experiment with new modes of transport. *Sage Open* 9. <https://doi.org/10.1177/2158244019841928>, 2158244019841928.
- Nguyen, M.H., 2021. Factors influencing home-based telework in Hanoi (Vietnam) during and after the COVID-19 era. *Transportation* 48, 3207–3238. <https://doi.org/10.1007/s11116-021-10169-5>.
- Nguyen, M.H., Armoogum, J., 2021. Perception and preference for home-based telework in the COVID-19 Era: a gender-based analysis in Hanoi, Vietnam. *Sustainability* 13, 3179. <https://doi.org/10.3390/su13063179>.
- Nguyen, M.H., Armoogum, J., 2020. Hierarchical process of travel mode imputation from GPS data in a motorcycle-dependent area. *Travel Behav. Soc.* 21, 109–120. <https://doi.org/10.1016/j.tbs.2020.06.006>.
- Nguyen, M.H., Armoogum, J., Nguyen Thi, B., 2021. Factors affecting the growth of E-shopping over the COVID-19 Era in Hanoi, Vietnam. *Sustainability* 13, 9205. <https://doi.org/10.3390/su13169205>.
- Nguyen, M.H., Pojani, D., 2022a. The emergence of recreational cycling in Hanoi during the Covid-19 pandemic. *J. Transport Health* 24, 101332. <https://doi.org/10.1016/j.jth.2022.101332>.
- Nguyen, M.H., Pojani, D., 2022b. Why are Hanoi students giving up on bus ridership? *Transportation*. <https://doi.org/10.1007/s11116-021-10262-9>.
- Nguyen, M.H., Pojani, D., 2021. Covid-19 need not spell the death of public transport: learning from Hanoi's safety measures. *J. Transport Health*. <https://doi.org/10.1016/j.jth.2021.101279>, 101279.
- Nguyen, N., 2021. Proposing vaccination for nearly 63,000 delivery riders in HCMC [Đề xuất tiêm vắc xin cho gần 63.000 shipper tại TP.HCM] [WWW Document]. *Báo Thanh Niên*. URL. <https://thanhnien.vn/post-1095399.html>, 10.14.2021.
- Nguyen, N.P.T., Hoang, T.D., Tran, V.T., Vu, C.T., Fodjo, J.N.S., Colebunders, R., Dunne, M.P., Vo, T.V., 2020. Preventive behavior of Vietnamese people in response to the COVID-19 pandemic. *PLoS One* 15, e0238830. <https://doi.org/10.1371/journal.pone.0238830>.

- Nguyen, T.H.D., Vu, D.C., 2020. Food delivery service during social distancing: proactively preventing or potentially spreading coronavirus disease–2019? *Disaster medicine and public health preparedness*, 14, pp. e9–e10. <https://doi.org/10.1017/dmp.2020.135>.
- Nguyen-Phuoc, D.Q., De Gruyter, C., Nguyen, H.A., Nguyen, T., Ngoc Su, D., 2020. Risky behaviours associated with traffic crashes among app-based motorcycle taxi drivers in Vietnam. *Transport. Res. F Traffic Psychol. Behav.* 70, 249–259. <https://doi.org/10.1016/j.trf.2020.03.010>.
- Nikkei Asia, 2021. Vietnam faces food delivery crisis in Ho chi Minh city [WWW document]. Nikkei Asia. URL. <https://asia.nikkei.com/Spotlight/Coronavirus/Vietnam-faces-food-delivery-crisis-in-Ho-Chi-Minh-City>, 10.1.2021.
- Ortiz-Prado, E., Henriquez-Trujillo, A.R., Rivera-Olivero, I.A., Lozada, T., Garcia-Bereguian, M.A., 2021. High prevalence of SARS-CoV-2 infection among food delivery riders. A case study from Quito, Ecuador. *Sci. Total Environ.* 770, 145225. <https://doi.org/10.1016/j.scitotenv.2021.145225>.
- Palmer, A., 2020. Amazon says more than 19,000 workers got Covid-19 [WWW Document]. CNBC. URL. <https://www.cnbc.com/2020/10/01/amazon-says-more-than-19000-workers-got-covid-19.html>, 9.28.2021.
- Papakostopoulos, V., Nathanael, D., 2021. The complex interrelationship of work-related factors underlying risky driving behavior of food delivery riders in Athens, Greece. *Safety and Health at Work* 12, 147–153. <https://doi.org/10.1016/j.shaw.2020.10.006>.
- Perencevich, E.N., Diekema, D.J., Edmond, M.B., 2020. Moving personal protective equipment into the community: face shields and containment of COVID-19. *JAMA* 323, 2252. <https://doi.org/10.1001/jama.2020.7477>.
- Pollard, M., O'Neill, C.T., 2020. How COVID-19 is impacting online food delivery platforms. CitiGPS. URL. <https://www.citivelocity.com/citigps/how-covid-19-is-impacting-online-food-delivery-platforms/>, 10.1.2021.
- Qin, H., Wei, Y., Zhang, Q., Ma, L., 2021. An observational study on the risk behaviors of electric bicycle riders performing meal delivery at urban intersections in China. *Transport. Res. F Traffic Psychol. Behav.* 79, 107–117. <https://doi.org/10.1016/j.trf.2021.04.010>.
- Rana, I.A., Bhatti, S.S., Aslam, A.B., Jamshed, A., Ahmad, J., Shah, A.A., 2021. COVID-19 risk perception and coping mechanisms: does gender make a difference? *Int. J. Disaster Risk Reduc.* 55, 102096. <https://doi.org/10.1016/j.ijdrr.2021.102096>.
- Remuzzi, A., Remuzzi, G., 2020. COVID-19 and Italy: what next? *Lancet* 395, 1225–1228. [https://doi.org/10.1016/S0140-6736\(20\)30627-9](https://doi.org/10.1016/S0140-6736(20)30627-9).
- Sankaran, J.K., Gore, A., Coldwell, B., 2005. The impact of road traffic congestion on supply chains: insights from Auckland, New Zealand. *Int. J. Logistics Res. Appl.* 8, 159–180. <https://doi.org/10.1080/13675560500166780>.
- Saphores, J.-D., Xu, L., 2020. E-shopping changes and the state of E-grocery shopping in the US - evidence from national travel and time use surveys. *Research in Transportation Economics* 100864. <https://doi.org/10.1016/j.retrec.2020.100864>.
- Shi, K., Cheng, L., De Vos, J., Yang, Y., Cao, W., Witlox, F., 2021. How does purchasing intangible services online influence the travel to consume these services? A focus on a Chinese context. *Transportation* 48, 2605–2625. <https://doi.org/10.1007/s11116-020-10141-9>.
- Statista, 2018. *eServices Report 2018 – Online Food Delivery*. Hamburg, Germany.
- Sultana, J., Mazzaglia, G., Luxi, N., Cancellieri, A., Capuano, A., Ferrajolo, C., de Waure, C., Ferlazzo, G., Trifirò, G., 2020. Potential effects of vaccinations on the prevention of COVID-19: rationale, clinical evidence, risks, and public health considerations. *Expert Rev. Vaccine* 19, 919–936. <https://doi.org/10.1080/14760584.2020.1825951>.
- Tabachnick, B.G., Fidell, L.S., 2000. *Using Multivariate Statistics*, 4 edition. Allyn & Bacon, Boston, MA.
- UNCTAD, 2021. *COVID-19 and E-Commerce: a Global Review*. eTrade for all. United Nations, Geneva New York.
- van Winsen, F., Wauters, E., Lauwers, L.H., de Mey, Y., Van Passel, S., Vancauteren, M., 2011. Combining risk perception and risk attitude: a comprehensive individual risk behavior model (No. 115749). In: 2011 International Congress, August 30–September 2, 2011, Zurich, Switzerland, 2011 International Congress, August 30–September 2, 2011. European Association of Agricultural Economists, Zurich, Switzerland.
- Vietnam E-Commerce Association VECOM, 2021. *Vietnam E-Commerce Index 2021 Report*. Hanoi.
- Wood, A.J., Graham, M., Lehdonvirta, V., Hjorth, I., 2019. Networked but commodified: the (Dis)Embeddedness of digital labour in the gig economy. *Sociology* 53, 931–950. <https://doi.org/10.1177/0038038519828906>.
- World Economic Forum, 2020. *The Future of the Last-Mile Ecosystem*. World Economic Forum, Geneva, Switzerland.
- World Health Organization, 2020. *Rational Use of Personal Protective Equipment (PPE) for Coronavirus Disease (COVID-19): Interim Guidance*, 19 March 2020 (No. WHO/2019-nCoV/IPC PPE_use/2020.2). World Health Organization.
- Wu, C.Y.H., Loo, B.P.Y., 2016. Motorcycle safety among motorcycle taxi drivers and nonoccupational motorcyclists in developing countries: a case study of Maoming, South China. *Traffic Inj. Prev.* 17, 170–175. <https://doi.org/10.1080/15389588.2015.1048336>.
- Yıldırım, M., Geçer, E., Akgül, Ö., 2021. The impacts of vulnerability, perceived risk, and fear on preventive behaviours against COVID-19. *Psychol. Health Med.* 26, 35–43. <https://doi.org/10.1080/13548506.2020.1776891>.
- Yu, R., Abdel-Aty, M., 2013. Multi-level Bayesian analyses for single- and multi-vehicle freeway crashes. *Accid. Anal. Prev.* 58, 97–105. <https://doi.org/10.1016/j.aap.2013.04.025>.
- Zheng, Y., Ma, Y., Guo, L., Cheng, J., Zhang, Y., 2019. Crash involvement and risky riding behaviors among delivery riders in China: the role of working conditions. *Transport. Res. Rec.* 2673, 1011–1022. <https://doi.org/10.1177/0361198119841028>.
- Zhou, Y., Wang, X., Cara, 2014. Explore the relationship between online shopping and shopping trips: an analysis with the 2009 NHTS data. *Transport. Res. Pol. Pract.* 70, 1–9. <https://doi.org/10.1016/j.tra.2014.09.014>.